KESAN ABU KULIT KUPANG (*Perna viridis*) SEBAGAI BAHAN TAMBAH DI DALAM KONKRIT TERHADAP PENGAWETAN LARUTAN SODIUM KLORIDA

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PENGHARGAAN

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ABSTRAK

Kulit kupang merupakan sisa akuakultur yang semakin meningkat seiring dengan penghasilan ternakan kupang di kawasan perairan Malaysia. Berdasarkan kajian terdahulu, kulit kupang sesuai digunakan di dalam campuran konkrit kerana komposisi kalsium karbonat ($CaCO_3$) yang tinggi iaitu melebihi 95% yang berpotensi menjadi bahan pengisi di dalam meningkatkan kebolehkerjaan serta ketahanan konkrit. Oleh yang demikian, kajian ini memfokuskan kepada penggunaan sisa kulit kupang serta keupayaannya apabila diaplikasikan sebagai bahan tambah di dalam campuran konkrit normal. Sisa kulit kupang ini dihancurkan menggunakan mesin pengisar bebola dan melepasi saiz ayakkan 75µm. Peratusan abu kulit kupang yang digunakan di dalam campuran konkrit adalah 0% (KN), 1% (KAKK1), 2% (KAKK2), 3% (KAKK3) dan 4% (KAKK4) dengan jumlah keseluruhan sebanyak 145 sampel. Kesemua sampel kemudiannya diawet menggunakan larutan sodium klorida (2.73%) dengan tempoh pengawetan 7, 28 dan 90 hari. Penyelidikan adalah melalui analisis serakan partikel (PSD), graviti tentu, masa pengerasan, ujian runtuhan, imbasan imej SEM (*Scanning Electron Microscopy*), analisis SEM-EDX (*Energy Dispersive X-Ray*), XRD (*X-Ray Difraction*), kekuatan mampatan, kekuatan tegangan pemisah dan serapan kapilari air air. Hasil daripada kesemua ujikaji setiap sampel, didapati konkrit KAKK1 memberikan nilai peratusan yang optimum. Berdasarkan analisis statistik yang dijalankan, peratusan campuran optimum abu kulit kupang yang sesuai adalah KAKK1 di mana ianya memberikan nilai signifikan kepada ciri mekanikal konkrit iaitu kekuatan mampatannya dengan nilai $p<0.007$, serapan kapilari air konkrit dengan $p<0.008$ bagi kebolehtelapannya dan hubungan korelasi yang kuat iaitu $r=0.99$ dan -0.93. Melalui peratusan ini, konkrit memberikan ciri-ciri positif terhadap kekuatan dan keupayaan apabila terdedah kepada persekitaran sodium klorida.

ABSTRACT

Mussel shell is a type of aquaculture waste that increasingly inline with mussel production in Malaysian coastal area. According to previous research, mussel shell are suitable to be used in concrete mixture due to its composition compound more than 95% of calcium carbonate ($CaCO_3$) content which potentially act as filler materials that can increasing concrete workability and durability. Thus, this present research focuses on the utilization of mussel shell waste and its potential when applied as an admixture in normal concrete. Mussel shell waste was crushed using a ball mill and sieved with mesh strainer passing through 75μm sieve size. An admixture of mussel shell ash with 0% (KN), 1% (KAKK1), 2% (KAKK2), 3% (KAKK3) and 4% (KAKK4) respectively were incorporated in concrete and were investigated with a total number of 145 sampels. The sampels were cured using 2.37% of sodium chloride (NaCl) solution for 7, 28 and 90 days respectively. Furthermore, the investigation was carried out based on laboratory analysis including particle size analysis (PSA), specific gravity, setting time, slump analysis, SEM (Scanning Electron Microscopy), SEM-EDX (SEM with Energy Dispersive X-Ray), XRD (X-Ray Diffraction), compressive strength, split tensile strength and water capillary absorption. According to the collected data from all investigation, KAKK1 reveals an achievable optimum percentage of concrete performance. Based on statistical analysis, the utilisation of KAKK1 allocate a significant value on its mechanical properties through compressions analysis with a value of $p<0.007$, water capillary absorption with $p<0.008$ on its permeability and imparting strongest correlation relationship with $r = 0.99$ and -0.93 as compared to control sampels KN. According to this percentages, concrete give an improvement on its strength and durability when exposed to sodium chloride environment.

ISI KANDUNGAN

SENARAI JADUAL

SENARAI RAJAH

SENARAI SINGKATAN

XRD	-	*X-Ray Difraction*
PSD	-	*Particle Size Distribution*
IC	-	*Ion Chromatography*
SPSS	-	*Statistical Package for the Social Sciences*
CSH	-	*Calcium Silicates Hydrates* @ Kalsium silikat terhidrasi
CH	-	*Calcium Hydroxide* @ kalsium hidroksida
GGBS	-	*ground granulated blastfurnace slag*
AKK	-	Abu Kulit Kupang
AKK1	-	Abu Kulit Kupang 1% + simen
AKK2	-	Abu Kulit Kupang 2% + simen
AKK3	-	Abu Kulit Kupang 3% + simen
AKK4	-	Abu Kulit Kupang 4% + simen
KN	-	Konkrit Normal
KAKK1	-	Konkrit Abu Kulit Kupang 1%
KAKK2	-	Konkrit Abu Kulit Kupang 2%
KAKK3	-	Konkrit Abu Kulit Kupang 3%
KAKK4	-	Konkrit Abu Kulit Kupang 4%
OPC	-	*Ordinary Portland Cement* @ simen Portland biasa
ppm	-	*parts per million*
ppb	-	*parts per billion*
MICP	-	*Microbiologically Induced Calcite Precipitation*
DMC	-	*Dimethyl Carbonate*

$CaCO_3$	-	Kalsium karbonat
CaO	-	Kalsium oksida
CO_2	-	Karbon dioksida
CO_3	-	Karbonat
Ca	-	Kalsium
NaCl	-	Sodium klorida
$MgCl_2$	-	Magnesium klorida
$MgSO_4$	-	Magnesium sulfat
Na_2SO_4	-	Sodium sulfat
CaCl	-	Kalsium klorida
CCA	-	Kalsium kloroaluminat
AFt	-	Fasa Alumina, Ferik oksida, pembentukan *Ettringite (tri-)*
AFm	-	Fasa Alumina,Ferik oksida, monosulfat
C_3S	-	Trikalsium silikat
C_2S	-	Dikalsium silikat
C_3A	-	Trikalsium aluminat
C_4AF	-	Tetrakalsium aluminoferit
H	-	Hidrogen @ *hydrogen*
As	-	Arsenik
Pb	-	Plumbum
Ba	-	Barium
F^-	-	Fluorida
NO_2^-	-	Nitrit
Br^-	-	Bromida
NO_3^-	-	Nitrat
PO_4^-	-	Fosfat
S	-	Sulfur

Al	-	*Aluminium*
Si	-	Silika
Cd	-	*Cadmium*
Cr	-	*Chromium*
Cs	-	*Cesium*
Cu	-	*Copper*
Ga	-	*Gallium*
Fe	-	Ferum @ Iron
K	-	Potassium
Mg	-	Magnesium
Li	-	*Lithium*
Mn	-	*Manganese*
Ni	-	*Nickel*
Al	-	Alumunium
As	-	Arsenik
Ba	-	Barium
Pb	-	Plumbum
Se	-	*Selenium*
Rb	-	*Rubidium*
Na	-	Sodium
Ag	-	*Silver*
Sr	-	*Strontium*
TL	-	*Thallium*
V	-	*Vanadium*
Zn	-	Zinc
$Ca(OH)_2$	-	Kalsium Hidroksida
F^-	-	Fluorida

NO_2^-	-	Nitrit
NO_3^-	-	Nitrat
Br^-	-	Bromida
PO_4^-	-	Fosfat
DV	-	Dependents variable / Pemboleh ubah bersandar
IV	-	Independents variable / Pemboleh ubah tak bersandar
BS EN	-	*British European Standard*
ASTM	-	*American society for testing and materials*
UTHM	-	Universiti Tun Hussein Onn Malaysia

SENARAI LAMPIRAN

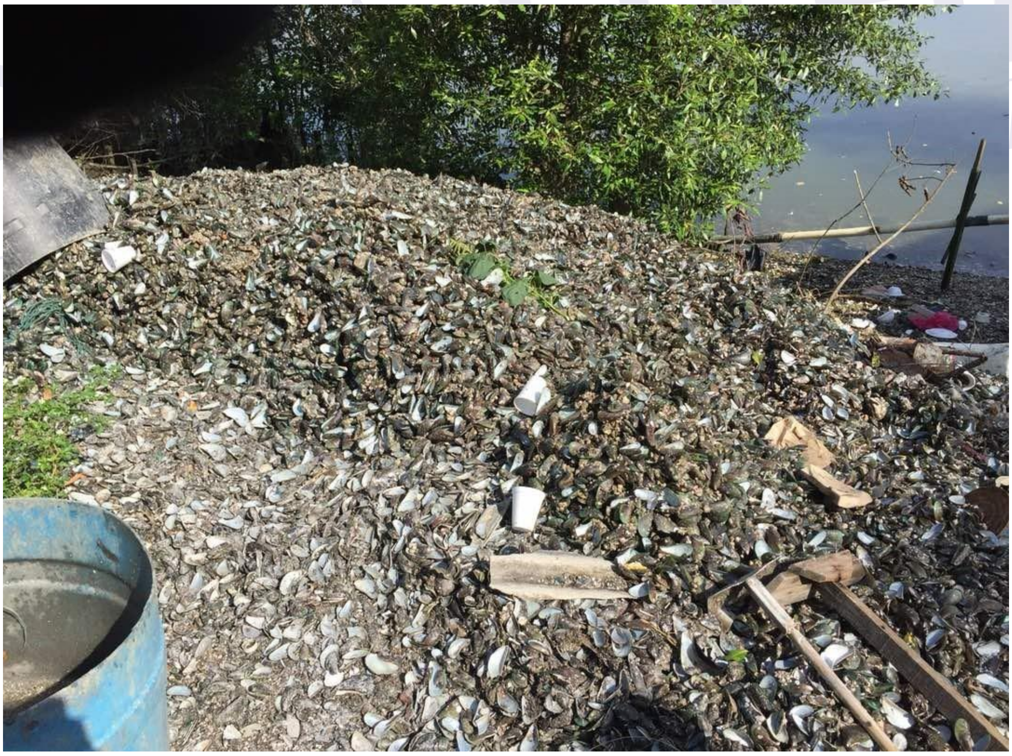
BAB 1

PENDAHULUAN

1.1 Latar belakang kajian

Masalah pengurusan sisa buangan merupakan salah satu faktor yang mencabar bagi negara-negara membangun terutamanya di rantau Asia. Penghasilan sisa ini dilihat memberikan impak negatif kepada negara di mana kadar penghasilannya kian meningkat setiap tahun dan ianya mengatasi keupayaan pihak-pihak yang berkaitan dalam mengawal pengurusan sisa pepejal ini (Malakahmad *et al*., 2017). Misalnya di Thailand, lebih daripada 15 juta tan sisa buangan terhasil setiap tahun (Lertwattanaruk *et al*., 2012) dan penjanaannya kian meningkat saban tahun seiringan dengan negara-negara Asia yang lain (Ibrahim *et al*., 2016). Menurut kajian Badgie *et al.* (2011), dijangkakan penjanaan purata jumlah sisa pepejal di rantau Asia ini akan meningkat kepada 1.8 juta tan iaitu sebanyak 5.2 juta meter padu setiap hari jika tidak dikawal. Oleh yang demikian, penghasilan sisa buangan ini diklasifikasikan sebagai pemasalahan global yang perlu dipandang serius dan ditangani dengan segera oleh semua pihak dalam mengawal penjanaannya setiap hari.

Berdasarkan kajian oleh Ali *et al.* (2012), faktor utama peningkatan sisa buangan adalah berpunca daripada peningkatan sosio ekonomi masyarakat selaras dengan peningkatan ekonomi dari segi perniagaan, perkilangan dan lain-lain. Di Malaysia, sektor perikanan merupakan salah satu sumber ekonomi yang banyak menyumbang kepada pendapatan negara. Berdasarkan kepada Jabatan Perikanan Malaysia (2017), sektor perikanan telah menyumbang sebanyak 1.1% kepada KDNK dan telah menyediakan peluang pekerjaan sebanyak 35,100 pekerjaan kepada para nelayan. Ternakan kupang merupakan salah satu aktiviti yang dijalankan di dalam sektor perikanan di Malaysia. Merujuk kepada statistik Jabatan Perikanan Malaysia (2017), telah berlaku peningkatan sebanyak 2,274.29 tan metrik siput sudu atau dikenali sebagai kupang dihasilkan pada tahun 2017 berbanding tahun sebelumnya iaitu sebanyak 1,827.27 tan metrik. Walaubagaimanapun, peningkatan ekonomi ini telah menyumbang kepada peningkatan sisa buangan (Ali *et al*., 2012) di mana 33% daripada hasil pengeluaran kupang adalah terdiri daripada sisa kulitnya (Martínez-García *et al*., 2017) yang akan dibuang setelah isinya diperolehi. Merujuk kepada kajian oleh Ibrahim *et al.* (2016), penjanaan sisa buangan yang terdapat di Malaysia ini telah meningkat daripada 22,000 tan pada tahun 2012 kepada 30,000 hingga ke 33,000 pada tahun 2013. Jika ianya tidak diatasi, peningkatan sisa buangan daripada penternakan kupang di dalam sektor ini akan meningkatkan lagi penjanaan sisa buangan yang sedia ada. Rajah 1.1 menunjukkan kawasan pembuangan kulit kupang di salah satu kawasan pemprosesan kupang.



Rajah 1.1: Sisa kulit kupang di Kampung Sungai Danga, Johor Bahru

Menurut Ibrahim *et al.* (2016), antara faktor sampingan yang mempengaruhi peningkatan sisa buangan adalah disebabkan oleh sikap masyarakat yang kurang prihatin terhadap kebersihan, kurang ketelitian dalam pengurusan sumber manusia, tempat penyimpanan dan pengangkutan bahan yang tidak efisien serta masalah dalam melupuskan sisa bahan tersebut. Oleh yang demikian, ianya perlu diatasi bagi memastikan peningkatan sisa buangan dapat dikurangkan serta mewujudkan sistem pengurusan sisa buangan yang lebih mampan.

Salah satu penyelesaian mudah kepada masalah peningkatan sisa bahan buangan ini adalah dengan cara menggunakan kaedah mengitar semula bahan di mana ianya dapat meminimumkan kuantiti pembuangan sisa buangan yang ada (Ali *et al*., 2012). Pelbagai kajian mengenai penggunaan semula kulit kupang telah dijalankan oleh para pengkaji bagi mengenalpasti potensi bahan tersebut apabila diaplikasikan di dalam industri supaya dapat mengurangkan lagi kuantiti sisa buangan dan ianya jelas memberikan tindak balas yang positif. Antaranya seperti kajian oleh Xiong *et al.* (2011) iaitu kaedah penggunaan semula bahan terdiri daripada abu kulit kupang sebagai media penapis bagi menyingkirkan fosfat yang terdapat di dalam air. Pengkalsinan kulit kupang pada suhu 700°C untuk 20 minit telah meningkatkan penyingkiran sulfat daripada 25% kepada 55%.

Di samping itu, kajian oleh Martínez-García *et al.* (2017) telah mengitar semula sisa kulit kupang sebagai bahan gantian batu baur di dalam konkrit biasa dan memberikan tindak balas yang positif terhadap ciri-ciri konkrit. Secara keseluruhannya, penggunaan semula sisa bahan kulit kupang di dalam kajian-kajian sebelumnya dilihat berpotensi digunakan semula sebagai bahan campuran di dalam konkrit. Oleh yang demikian, kajian ini memfokuskan kepada penggunaan semula sisa kulit kupang sebagai bahan tambah di dalam konkrit dan ianya diharapkan dapat mengurangkan kuantiti sisa buangan kulit kupang yang ada di samping dapat meningkatkan lagi kekuatan konkrit.

1.2 Penyataan masalah

Ketahanan konkrit merupakan perkara yang perlu dititikberatkan di dalam pembinaan kerana ianya memainkan peranan terhadap kebolehkhidmatan sesuatu bangunan dan struktur itu. Pendedahan struktur konkrit kepada persekitaran agresif yang mengandungi ion-ion seperti klorida, sulfat, karbon dioksida dan pelbagai lagi sama ada secara semula jadi ataupun daripada sisa industri dapat memberi kesan buruk terhadap ketahanan serta kekuatan konkrit disebabkan oleh kebolehtelapannya yang tinggi (Neville, 2011). Misalnya seperti pembangunan di kawasan laut, di mana ianya semakin banyak diaplikasikan di dalam industri pembinaan kini terutamanya di dalam sektor perlancongan. Namun, kebanyakan pembangunan di kawasan laut hanya menggunakan simen khas sahaja seperti simen rintangan sulfat, simen Portland Pozolana dan pelbagai lagi berbanding simen Portland biasa. Ini kerana, adunan simen Portland ini mempunyai kadar rintangan rendah terhadap serapan ion-ion agresif di dalam komposisi air laut disebabkan strukturnya yang berliang (Yang *et al*., 2017).

Sodium klorida (NaCl) merupakan salah satu sebatian yang terkandung di dalam air laut di mana ianya terbentuk daripada gabungan antara ion sodium (Na^+) dan juga klorida (Cl^-) (Mehta & Monteiro, 2014). Menurut Neville (2011), secara lazimnya sebatian NaCl ini merangkumi 78% daripada keseluruhan kemasinan air laut dan secara tidak langsung menjadikan ia sebatian tertinggi dan utama berbanding sebatian lain seperti magnesium klorida (MgCl) dan magnesium sulfat ($MgSO_4$) (15%). Sodium klorida diklasifikasikan sebagai sejenis garam yang merbahaya terkandung di dalam air laut yang berpotensi mendatangkan keburukan terhadap kekuatan dan ketahanan konkrit daripada tindak balas kimianya (Farnam *et al*., 2016).

Berdasarkan kajian oleh Qiao *et al*. (2018), beliau mendapati kemasukan garam NaCl ke dalam konkrit membentuk garam *Friedel*. Pembentukan garam ini menyebabkan konkrit kehilangan kekuatan tegangan disebabkan penguraian kalsium hidroksida ($Ca(OH)_2$) dan kalsium silika terhidrasi (CSH) disamping tekanan daripada pembentukan kristal garam *Friedel* di dalam struktur konkrit. Manakala, interaksi antara konkrit terhadap klorida dan juga ion sampingan seperti sulfat juga akan membawa ke pengubahsuaian ciri-ciri dalaman konkrit tersebut (Ragab *et al*., 2016). Selain itu, ia juga akan membuatkan konkrit musnah, kehilangan ikatan antara adunan simen serta kehilangan kekuatan pada batu baur (Gruyaert *et al*., 2012). Oleh yang demikian, kebolehtelapan konkrit harus dikurangkan bagi mengelakkan daripada kemasukan ion-ion tersebut ke dalam konkrit yang dapat mengubah suai struktur serta ciri-ciri di dalamnya.

Berdasarkan perspektif ekonomi, aktiviti penternakan kupang ini merupakan salah satu kegiatan perikanan yang semakin mendapat perhatian dalam kalangan perniaga-peniaga barangan basah dan juga daripada sektor awam seperti Jabatan Perikanan Malaysia. Berdasarkan sumber daripada BERNAMA (2015), Jabatan

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